National Marine Fisheries Service

Interim Guidance for Evaluating Sediment Quality and Environmental and Ecological Risk Factors for Dredging Activities

Purpose and Need: The purpose of this document is to provide guidance on interpreting sediment quality data for dichlorodiphenyl trichloroethane (DDT), polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) for use in Endangered Species Act (ESA) and Magnuson-Stevens Fishery Conservation and Management Act (MSA) Essential Fish Habitat (EFH) consultations on dredging activities in the Northwest Region.

This guidance is needed to address a subset of ecological and technical limitations in the Northwest Regional Sediment Evaluation Framework (SEF) regarding the risks sediment-associated contaminants pose to designated critical habitat, primary constituent elements forage and water quality(Table 2); listed salmon and steelhead (Table 2); ESA conservation goals; and EFH and EFH managed species (Table 3).

It is the intent of the National Marine Fisheries Service (NMFS) to use a single set of numeric criteria for sediment quality in the region. Therefore, once marine and freshwater sediment criteria for benthic invertebrates have been developed and incorporated into the SEF with concurrence, those criteria will replace the interim sediment quality criteria, i.e., invertebrate adjusted effects thresholds, in this document.

Ecological and Technical Limitations:

1. The SEF is a technical framework for sediment testing and dredge material management. The intent of the sediment quality criteria is to protect benthic invertebrates at the biological community-level, not the population-level.

The term “protect” does not necessarily mean there are no adverse effects, e.g., survival, reproduction, growth, behavior, to benthic invertebrates at the community-level, but sediments at or below SL1 criteria are likely to be statistically protective of 100 percent of the benthic invertebrate community, although it may also be true that the SL1 criteria are statistically protective of only 75 percent of the benthic invertebrate community. Therefore, the SL1 criteria are statistically protective of ≤100 percent to ≥75 percent of the benthic invertebrate community.

The SL2 criteria are indicators of moderate to severe adverse effects, i.e., statistically measurable effects, on the benthic invertebrate community and provide a minimum level of protection of 75 percent, i.e., ≤75 percent.

Between the SL1 and SL2 criteria, moderate adverse effects on the benthic invertebrate community are likely, with a level of protection statistically equal to <100 percent but > 75 percent.

While the intent of the SL1 criteria are to function as indicators of no effects criteria, i.e., statistically no measurable effects, SL1 criteria may or may not be sufficiently protective of salmon prey, which are primarily epibenthic invertebrates. SL2 criteria likely pose a risk to epibenthic invertebrates at the population level based on the inherent adverse effects associated with the criteria.

The central issues with SL1 and SL2 criteria are: (1) test organisms likely under represent species sensitivity across the benthic invertebrate community; (2) sediment criteria do not fully consider the effects of chemical mixtures and additive effects; (3) the sediment thresholds in the SEF overwhelmingly represent thresholds associated with apparent effect thresholds (AETs) (AETs represent the concentration in sediment above which adverse biological effects are always expected for a particular biological indicator); (4) AETs are not based on dose-response correlations, have no predictive power, violate several assumptions, such as independence among the test observations, and are based on laboratory bioassays where mortality is the main endpoint, i.e., all of the relevant AETs, i.e., amphipod mortality, benthic abundance, embryo mortality, and embryo abnormality, are based on lethality; and (4) no clear relationship between criteria protectiveness for benthic invertebrates and epibenthic invertebrates that are exposed to water column sediment-associated contaminant plumes.

2. The current method to test whether there really is a risk (toxicity), i.e., sediment bioassays with invertebrates, does not address direct effects of the contaminants on fishes.

3. The SEF does not consider the environmental and ecological risks, e.g., multiple exposure pathways, that are interconnected to dredging activities and contaminant exposure pathways experienced by salmon and steelhead and EFH managed species. For example, in the lower Columbia River, chemicals, such as DDT, PCBs, and PAHs are on the Clean Water Act (CWA) 303(d) list, which means that ambient water column concentrations for DDT, PCBs, and PAHs are at levels that do not protect at least one or more beneficial uses, e.g., salmon, from acute and chronic toxicity.

In addition to water column DDT, PCBs, and PAHs toxicity, the scientific literature [(1, 2, 3)] has shown that whole-body fish tissue concentrations and bioaccumulation of DDT, PCBs, and PAHs in juvenile salmon from sediment/prey ingestion in the Columbia River Basin and Puget Sound are at levels likely to impair growth, survival, and reproduction, in addition to sublethal effects such as immune dysfunction, hormonal alterations, enzyme induction, neurotoxicity, behavioral responses, disease susceptibility, and mutagenicity.

4. In practice, the numeric guidelines in the SEF tend to be applied as risk/no risk environmental and ecological indicators.

5. Sublethal effects, such as reproductive impairment, on juvenile salmon, via sediment/prey ingestion, can occur at tissue concentrations that are from 10 to 100 times lower than those for lethality [4]. Therefore, sediment test results for DDT, PCBs, and

PAHs with concentrations in the AET range are likely to pose an adverse risk to salmon due to the causal link between sublethal effects on juvenile salmon via sediment/prey ingestion.

Therefore, in the context of the ESA, the SEF may best function as a habitat-based risk assessment, with an adverse effects probability ratio of 1:4 for SL1 criteria, and an adverse effects probability ratio of 2:4 for SL2 criteria on salmon and steelhead prey, even if the criteria are protective (statistically) of the biological invertebrate community.

What the SEF is and what it is not: The SEF is a technical framework for sediment testing and dredge material management. The SEF is not a comprehensive analysis of the risks sediment-associated contaminants pose to fish and/or salmon and steelhead invertebrate prey. Therefore, sediment evaluation report results that are compared to SEF numeric guidelines should not and cannot be viewed as a sufficient technical basis to ensure a lack of adverse effects or harm to fish and/or salmon and steelhead invertebrate prey.

Sediment Thresholds and Multiple Lines of Evidence: Sediment-associated contaminants and their respective numeric thresholds, as applied in the SEF, are the principal factors taken into consideration for dredged material management decisions and determining environmental and ecological risks associated with dredging activities. However, sediment toxicity is only one of several risk factors that must be considered in an ESA and MSA consultation. Frequently, sediment toxicity and environmental and ecological risk factors, e.g., ambient water column toxicity, whole-body fish tissue concentrations, fish residence time, sediment mixtures and additive effects, are not systematically included as part of an exposure assessment which is likely to underestimate short term and long term risks sediment-associated contaminants pose to fish and/or salmon and steelhead invertebrate prey.

As part of this interim guidance, NMFS developed a set of tables, two each for DDT, PCBs, and PAHs, one for marine and one for freshwater systems, respectively. These tables identify chemical-specific parameters and effect thresholds based on available data. The criteria in the tables have a two-fold purpose: (1) to evaluate sediment-associated contaminant effects on salmon prey (invertebrates) with the use of habitat-based sediment effect thresholds, and (2) evaluate sediment-associated contaminant effects on fishes with the use of tissue-based sediment effect thresholds (marine only).

For PCBs and PAHs (marine), the tissue-based sediment effect thresholds are based on values developed by the Northwest Fisheries Science Center ([1, 2, 3]). For DDT (marine only), NMFS developed a system-averaged biota-sediment availability factor using the following formula and data sources:

$$\mathbf{(C_1/F_1)/(Cs/Foc)}$$

C_1 = the compound concentration in tissue – whole body
F_1 = the fraction of lipid in tissue
Cs = the compound's concentration in sediment
Foc = the fraction of organic carbon in sediment

C_1 is based on whole body tissue concentrations (dry weight) with effects on early life stages of salmon [3].
F_1 is based on the mean percent whole-body lipid content for smolt-stage salmon [1].
Cs is based on a subset of values (average) from sediment evaluation reports for the Columbia River Basin and the Oregon coast.
Foc is based on percent organic carbon in sediments in the Columbia River Basin, Washington and Oregon [5].

The habitat-based sediment effect thresholds are based on correlative sediment quality guidelines and associated effect ranges, i.e., Threshold Effect Levels (TEL), Threshold Effect Concentrations (TEC), Probable Effect Levels (PEL), and Probable Effect Concentrations (PEC). TELs and TECs are intended to identify the concentrations of sediment-associated contaminants below which adverse effects on benthic invertebrates are not expected to occur. PELs and PECs are intended to identify the concentrations of sediment-associated contaminants above which adverse effects on benthic invertebrates are likely to be observed. NMFS intent here is not to establish "no effect" criteria, but to provide a threshold that represents a low level of effect, i.e., an effects threshold that is reasonably certain to be protective of benthic and epibenthic invertebrates at the population level. To do this, NMFS calculated the geometric mean of the available sediment quality data ([6, 7]) for each threshold and chemical group to generate an adjusted effects threshold that represents criteria that are above the TEL/TEC criteria and below the PEL/PEC criteria.

Although the data sets used to generate the TEL, TEC, PEL, and PEC criteria have similar technical shortcomings as those for AET criteria, NMFS believes it is appropriate to use biologically conservative sediment quality criteria where there are threatened and endangered species and no region-specific sediment quality guidelines are available.

For PCBs (marine and freshwater), NMFS will use the SEF benthic invertebrate criteria with the assumption that these criteria are protective of salmon prey at the biological community-level.

<u>Sediment Screen Values:</u> Sediment screening values include benthic invertebrate thresholds, fish tissue-based sediment effect thresholds and an adjusted effects threshold for benthic invertebrates for DDT, PCBs, and PAHs.

<u>Environmental and Ecological Risk Factors:</u> The environmental and ecological risk factors are intended to assess the probability, severity and magnitude of adverse effects on salmon and steelhead exposed to multiple environmental stressors. The intent of this document is to place sediment-associated contaminants in a broader ecological context that considers the array of environmental stressors salmon and steelhead experience in the field with consideration of the long-term ecological effects sediment-associated contaminants pose to fish, salmon and steelhead invertebrate prey, and in-stream habitat characteristics.

The minimum set of environmental and ecological risk factors to be considered include fish residence and exposure risk potential, CWA 303(d) listings for DDT, PCBs, and PAHs[1]; whole-body fish tissue concentrations for DDT [8] and PCBs [1]; and sediment mixtures for fish and invertebrates using a logistic regression model.

The environmental and ecological risk factors are rated from low to high. High-rated risk factors are intended to highlight factors that pose a significant risk to salmon and steelhead and/or critical habitat.

For information on fish residence and exposure risk potential, indicate species and life stages present, abundance, based on adult emigration, juvenile rearing and out-migration timing, and indicate the overall level of risk of exposure and adverse effects to fish based on consideration on all environmental and ecological risk factors.

For information on CWA 303(d) listings, if any or all of the parameters are listed, mark the appropriate cell with a yes or no.

For information on whole-body fish tissue concentrations, indicate concentration relative to lipid concentration (Table 1), if data are available or if there is a need to collect fish on-site.

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[1] DDT, PCBs and PAHs are focal parameters in this document. However, the biological assessment or biological opinion should identify all 303(d) parameters listed for a respective water body as part of the environmental baseline and include those parameters in the exposure analysis.

Table 1. Residue Effect Threshold (RET) for PCBs in Salmonids [1]

RET µg g^{-1} lipid	Whole-fish lipid (% dry wt.)	Whole –fish lipid (% wet wt.)	RET ng g^{-1} lipid wet wt.	RET ng g^{-1} lipid dry wt.
2.4	5	1	24	120
2.4	10	2	48	240
2.4	15	3	72	360
2.4	20	4	96	480
2.4	25	5	120	600
2.4	30	6	144	720
2.4	35	7	168	840
2.4	40	8	192	960

For sediment mixtures, the following formula is recommended:

Σ (SMPAHs+SMPCBs+SMDDT)

Individual chemical concentrations are calculated as follows:

$$\text{SMPAHs} = \frac{S/T + S/T \ldots S/T}{n}$$

$$\text{SMPCBs} = \frac{S/T + S/T \ldots S/T}{n}$$

$$\text{SMDDT} = \frac{S/T + S/T \ldots S/T}{n}$$

SM = Sediment mixtures. S = sample concentration. T = threshold concentration.
n = number of samples.

Record the summed values in the appropriate cells for fish and invertebrates. The PAHs+PCBs+DDT sum for fish and invertebrates should be recorded on all three spreadsheets once the values for each chemical have been calculated. If the summed value of the samples for a dredge material management unit (DMMU) is less than one, it is unlikely that sediment mixtures of PAHs, PCBs, and DDT pose an appreciable risk to fish and/or salmon and steelhead invertebrate prey. If the summed value of the samples for a DMMU is greater than or equal to one, it is likely that sediment mixtures of DDT, PCBs, and PAHs pose an appreciable risk to fish and/or salmon and steelhead invertebrate prey, and decisions regarding dredged material management, including disposal methods, locations and timing, will need to be reconsidered for that DMMU.

<u>**Sediment Test Results:**</u> Record sediment test results for each chemical parameter for each sample. Total values are based on simple addition of each sample and corresponding chemical parameter.

<u>Application:</u> The environmental and ecological risk factors, plus the sediment screening criteria need to be considered collectively so compounding effects are given consideration. The information in the attached spreadsheets (completed on a project-by-project basis) is intended for use in biological assessments and/or biological opinions with a qualitative assessment of the information in the spreadsheets to explain the overall results in the respective document. The spreadsheets should be completed and attached as an appendix and referenced in the exposure analysis.

For each spreadsheet, record information on project timing, project location, proposed disposal method, and quantity in the appropriate cells.

For all three chemicals, the total value needs to be given greater consideration than individual isomers, congeners, metabolites, etc. For DDT, the emerging consensus is that sediment criteria and biological effects should probably be for individual isomers. However, the data at this time is not sufficient to link specific biological effects to individual isomers. Until data-specific biological effects to benthic invertebrates, epibenthic invertebrates, and fishes from exposure to individual DDT isomers is available NMFS will continue to evaluate exposure based on total DDT.

If any of the effect thresholds for fish tissue-based sediment effects thresholds, invertebrate effect thresholds, SEF thresholds, are exceeded, decisions regarding dredged material management, including disposal methods, locations, timing, will need to be reconsidered for that DMMU.

If the environmental and ecological risk factors for fish abundance (with a high rating), whole-body fish tissue concentrations, sediment mixture sums (fish or invertebrates) for DDT, PCBs, or PAHs are exceeded (or calculated--sediment mixture sums) and sediment samples are above or below the effect thresholds for DDT, PCBs, or PAHs, decisions regarding dredged material management, including disposal methods, locations and timing, will need to be reconsidered for that DMMU.

If none of the high-rated environmental and ecological risk factors are exceeded and sediment test results are below the each threshold for DDT, PCBs, or PAHs, the overall risks of harm to fish and/or salmon and steelhead invertebrate prey base from chemical exposure does is likely to be low, and decisions regarding dredged material management do not need to be reconsidered for that DMMU.

In application, caution needs to be exercised when using this interim guidance to take into account the significance of the adverse effect on critical habitat, i.e., forage-salmon prey and water quality, with particular attention to the duration and magnitude of the effect and the consequence on the function or value of the affected primary constituent elements, and consideration of whether the effect really affects the ability of the primary constituent element to support a recovering population as part of any discussion and/or decision regarding dredge material management.

Literature:

[1] Meador. J.P., Collier, T.K., and Stein. J.E. 2002. Use of tissue and sediment- based threshold concentrations of polychlorinated bipheynls (PCBs) to protect juvenile salmonids listed under the U.S. Endangered Species Act. Aquatic Conserv: Mar. Freshw. Ecosyst. 12: 493-516.

[2] Johnson, L.L, Collier, T.K., and Stein, J.E. 2002. An analysis in support of sediment quality thresholds for polycyclic aromatic hydrocarbons (PAHs) to protect estuarine fish. Aquatic Conserv: Mar. Freshw. Ecosyst. 12: 517-538.

[3] Northwest Fisheries Science Center. 2001. Potential impacts of toxic contaminants in salmonids and prey from the Columbia River estuary.

[4] Meador. J.P., Collier, T.K., and Stein. J.E. 2002. Determination of a tissue and sediment threshold for tributyltin to protect juvenile salmonids listed under the U.S. Endangered Species Act. Aquatic Conserv: Mar. Freshw. Ecosyst. 12: 539-551.

[5] Hedges, J.I., Turin, H.J., and Ertel, J.R. 1984. Sources and distributions of sedimentary organic matter in the Columbia River drainage basin, Washington and Oregon. Limnology and Oceanography, 29(1), 35-46.

[6] MacDonald, D.D. 1994. Approach to the assessment of sediment quality in Florida coastal waters.

[7] MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems.

[8] Beckvar, N., Dillon, T.M., Read, L.B. 2005. Approaches for linking whole-body fish tissue residues of mercury and DDT to biological effects thresholds. Environmental Toxicology and Chemistry, V. 24, No. 8, pp. 2094-2105.

Table 2. Federal Register notices for final rules that list species, designate critical habitat, or apply protective regulations to listed species in Oregon, Washington and Idaho.

Salmon	Listing Status	Critical Habitat	Protective Regulations
Chinook salmon (*Oncorhynchus tshawytscha*)			
Lower Columbia River	T 3/24/99; 64 FR 14308; T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Willamette River spring-run	T 3/24/99; 64 FR 14308; T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Upper Columbia River spring-run	E 3/27/99; 64 FR 14308; E 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	ESA section 9 applies
Snake River spring/summer run	T 4/22/92; 57 FR 14653; T 6/28/05; 70 FR 37160	10/25/99; 64 FR 57399	6/28/05; 70 FR 37160
Snake River fall-run	T 6/3/92; 57 FR 23458; T 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	6/28/05; 70 FR 37160
Puget Sound Chinook salmon	T 3/24/99 64 FR 14307; T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Chum salmon (*O. keta*)			
Columbia River	T 3/25/99; 64 FR 14508; T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Hood Canal summer-run chum salmon	T 3/25/99 64 FR 14507; T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	6/28/05; 70 FR 37160
Coho salmon (*O. kisutch*)			
Lower Columbia River	T 6/28/05; 70 FR 37160	Not applicable	6/28/05; 70 FR 37160
Southern Oregon/Northern California Coasts	T 6/28/05; 70 FR 37160	5/5/99; 64 FR 24049	6/28/05; 70 FR 37160
Sockeye salmon (*O. nerka*)			
Snake River	E 11/20/91; 56 FR 58619; E 6/28/05; 70 FR 37160	12/28/93; 58 FR 68543	ESA section 9 applies
Steelhead	**Listing Status**	**Critical Habitat**	**Protective Regulations**
Steelhead (*O. mykiss*)			
Lower Columbia River	T 3/19/98; 63 FR 13347 T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	7/10/00; 65 FR 42422
Upper Willamette River	T 3/25/99; 64 FR 14517 T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	7/10/00; 65 FR 42422
Middle Columbia River	T 3/25/99; 64 FR 14517 T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	7/10/00; 65 FR 42422
Upper Columbia River	E 8/18/97; 62 FR 43937 T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	ESA section 9 applies
Snake River Basin	T 8/18/97; 62 FR 43937 T 6/28/05; 70 FR 37160	09/02/05; 70 FR 52630	7/10/00; 65 FR 42422

Table 3. Species with Designated EFH in the States of Oregon and Washington. Species with Designated EFH in the State of Idaho include Chinook salmon and coho salmon.

Groundfish Species		**Groundfish Species**	
Leopard Shark	*Triakis semifasciata*	Tiger Rockfish	*Sebastes nigrocinctus*
Soupfin Shark	*Galeorhinus zyopterus*	Vermillion Rockfish	*Sebastes miniatus*
Spiny Dogfish	*Squalus acanthias*	Yellowtail Rockfish	*Sebastes reedi*
California Skate	*Raja inornata*	Arrowtooth Flounder	*Atheresthes stomias*
Spotted Ratfish	*Hydrolagus colliei*	Butter Sole	*Isopletta isolepis*
Lingcod	*Ophiodon elongatus*	Curlfin Sole	*Pleuronichthys decurrens*
Cabezon	*Scorpaenichthys*	Dover Sole	*Microstomus pacificus*
Kelp Greenling	*Hexagrammos*	Flathead Sole	*Hippoglossoides elassodon*
Pacific Cod	*Gadus macrocephalus*	Petrale Sole	*Eopsetta jordani*
Pacific Whiting	*Merluccius productus*	Sand Sole	*Psettichthys melanostictus*
Black Rockfish	*Sebastes maliger*	Longnose Skate	*Raja rhina*
Bocaccio	*Sebastes paucispinis*	Sablefish	*Anoplopoma fimbria*
Brown Rockfish	*Sebastes auriculatus*	Canary Rockfish	*Sebastes pinniger*
Copper Rockfish	*Sebastes caurinus*	China Rockfish	*Sebastes nebulosus*
Quillback Rockfish	*Sebastes maliger*	Darkblotched Rockfish	*Sebastes crameri*
English Sole	*Pleuronectes vetulus*	Greenstriped Rockfish	*Sebastes elongatus*
Pacific Sanddab	*Citharichthys sordidus*	Big Skate	*Raja binoculata*
Rex Sole	*Glyptocephalus zachirus*	Starry Flounder	*Platichthys stellatus*
Rosy Rockfish	*Sebastes rosaceus*	Rock Sole	*Lepidopsetta bilineata*
Rougheye Rockfish	*Sebastes aleutianus*	Pacific Ocean Perch	*Sebastes alutus*
Sharpchin Rockfish	*Sebastes zacentrus*	Redbanded Rockfish	*Sebastes babcocki*
Shortspine Thornyhead	*Sebastolobus alascanus*	Redstripe Rockfish	*Sebastes proriger*
Stripetail Rockfish	*Sebastes saxicola*	Rosethorn Rockfish	*Sebastes helvomaculatus*
Coastal Pelagic Species			
Pacific Sardine	*Sardinops sagax*		
Pacific (Chub) Mackerel	*Scomber japonicus*		
Northern Anchovy	*Engraulis mordax*		
Jack Mackerel	*Trachurus symmetricus*		
California Market Squid	*Loligo opalescens*		
Pacific Salmon Species			
Chinook Salmon	*Oncorhyncus tshawytcha*		
Coho Salmon	*Oncorhyncus kisutch*		
Puget Sound Pink Salmon (Washington)	*Oncorhyncus gorbuscha*		